Instruction Booklet No. T.R. 2538

INSTRUCTIONS

FOR THE USE AND CARE OF THE

CAMBRIDGE VERSATILE GALVANOMETER

This book is intended for the man who has charge of the instrument

CAMBRIDGE INSTRUMENT COMPANY, LTD.
13, GROSVENOR PLACE, LONDON, S.W.1
Works: LONDON AND CAMBRIDGE

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THE CAMBRIDGE VERSATILE GALVANOMETER AND ACCESSORIES

This range of instruments has been designed for use in electrical laboratories and test rooms where a wide range of current and voltage measurements may be required. No attempt has been made to compete with multi-purpose portable test sets but rather to provide accurate equipment which may be readily grouped together for any series of electrical measurements.

The equipment comprises one or more Unipivot indicators of standardised range with a series of ranging accessories which may be connected to the indicator either directly or through switches so that currents and voltages in various parts of a circuit may be measured in succession on the same indicator.

The Versatile Galvanometer

The Unipivot indicator carries two scales: a linear mV scale which is a direct calibration of the meter and a THERMAL or square law scale which is used when thermal accessories are connected. Both scales subtend the same angle and are figured 0–120. Ranges are, however, normally defined as the current or voltage to give a deflection of 100 scale divisions.

Two pairs of terminals are provided, giving ranges and characteristics as outlined below:—

Current for 100 divisions ... 200 μA. Scale factor $\times$ 2

Millivolts for 100 divisions—

At left-hand terminals	...	100 mV	„	„ $\times$ 1
At right-hand terminals	...	2 mV	„	„ $\times$ 0.02

Temperature Coefficient of Indication:—

200 μA Range	+.002% per °C.
100 mV Range	+0.02% per °C.
2 mV Range	—0.4% per °C.

The circuit resistance at the 2.4 mV terminals is 10 ohms entirely of copper while a constantan resistor brings the resistance to 500 ohms at the 120 mV terminals.

The Unipivot Galvanometer may be used on any reasonably level bench preferably of non-magnetic material. Magnetic screening is provided, however, and if used on a thick iron bench the calibration will not change by more than 0.5%. The change of indication due to a uniform field of 5 gauss is not more than 1%.

A clamp is provided which prevents damage to the pivot during transit.

D.C. Range Multipliers

These are single range shunts or series resistors which, when connected to the Versatile Galvanometer, provide ranges as indicated below. The units are provided with tongues for direct connection to the 120 mV range of the indicator but they may be connected via longer leads provided the added resistance is negligible compared with 500 ohms.

VOLTAGE MULTIPLIERS				CURRENT MULTIPLIERS		
Volt Range 100 Divs.	Scale Multiplying Factor	Terminal Resistance ohms		Range for 100 Divs-	Scale Multiplying Factor	Resistance ohms
		Connected	Meter Disconnected			
0.2	.002	1,000	INF	500μA	5	200
0.5	.005	2,500	INF	1,000μA	10	100
1.0	.01	5,000	INF	2mA	.02	50
2.0	.02	10,000	INF	5mA	.05	20
5	.05	10,000	10,133	10mA	.1	10
10	.1	20,000	20,133	20mA	.2	5
20	.2	40,000	40,133	50mA	.5	2
50	.5	50,000	50,025	100mA	1	1
100	1	60,000	60,000	200mA	2	.5
200	2	60,000	60,000	500mA	5	.2
400	4	120,000	120,000	1 A	.01	.1
500	5	150,000	150,000	2 A	.02	.05
				5 A	.05	.02
				10 A	.1	.01
				20 A	.2	.005

For higher currents a series of shunts is available providing extension of range to 2,000A for 100 divisions. Voltage multipliers for higher ranges are sometimes available to special order.

Temperature coefficient of indication when used with DC Range multipliers is not greater than $\pm 0.02\%$ per °C. rise.

D.C. range multipliers are adjusted to within plus or minus 0.1% of correct value.

Voltage multiplier series resistances are connected in the positive lead so that the indicator is at the potential of the negative terminal.

D.C. Range Box

This accessory connected by links or leads to the Versatile galvanometer provides a series of D.C. voltage and current ranges selected by switches. Separate terminals are provided for voltage and current while a selector switch, which may be operated on load, allows the instrument to be connected so as to measure voltage and current in turn. The voltage range series resistors are connected in the positive lead so that the galvanometer is at the potential of the negative terminal.

The following ranges are provided:

VOLTAGE RANGES				CURRENT RANGES			
Volt Range for 100 Divs.	Scale Multiplying Factor	Resistance ohms		Current Range for 100 Divs.	Scale Multiplying Factor	Resistance ohms	
		Connected	When measuring current			Connected	When measuring voltage
0.1	.001	500	INF	0.2mA	.002	500	INF
0.2	.002	1,000	INF	1mA	.01	100	125
1.0	.01	5,000	INF	2mA	.02	50	55.6
2.0	.02	10,000	INF	10mA	.1	10	10.2
10	.1	50,000	INF	20mA	.2	5	5.05
20	.2	100,000	INF	100mA	1	1	1.00
100	1	500,000	INF	200mA	2	.5	.5
200	2	500,000	500,000	1A	.01	.1	.1
1,000	10	500,000	500,000	2A	.02	.05	.05
				10A	.1	.01	.01

Temperature coefficient of indication: Not more than $\pm 0.02\%$ per °C. rise.

All resistors are adjusted to within plus or minus 0.1%.

A.C. Range Box

This accessory connected to the 120 mV terminals of the Versatile Galvanometer converts the equipment into a multirange rectifier voltmeter and ammeter, the indication being read on the linear or mV scale.

Rectifier meters of this type measure the mean value of current or voltage but for convenience the A.C. Range box is adjusted, using a sine wave form, so that the scale represents RMS values. If the form factor of the waveform subsequently used differs from 1.11, the meter will be in error, but for a wide variety of waveforms:

Mean value applied = scale reading × 0.9.

R.M.S. value applied = scale reading × 0.9 × Form Factor.

The range box incorporates a transformer and should not be used in circuits carrying a D.C. component.

The characteristics and available ranges are as outlined in the table below.

VOLTAGE RANGES			CURRENT RANGES		
Volt Range for 100 Divs.	Scale Multiplying Factor	Resistance ohms	Current Range for 100 Divs.	Scale Multiplying Factor	Approximate Impedance at 50 c/s ohms.
1	.01	10	1mA	.01	1,000
2	.02	20	2mA	.02	300
10	.1	1,000	10mA	.1	50
20	.2	2,000	20mA	.2	23
100	1	50,000	100mA	1	.8
200	2	100,000	200mA	2	.3
1,000	10	500,000	1A	.01	.02
			2A	.02	.01
			10A	.1	.004

Frequency Range : The calibration at any frequency between 5 c/s and 10,000 c/s does not differ by more than about 2% from that at 50 c/s.

Temperature coefficient : This varies with range and indication, but is approximately —0.07% per °C.

Accuracy and Overload Capacity : Range boxes are adjusted to have errors of not more than plus or minus 0.5% full scale. These errors may change a little as the rectifier ages and overloads may cause changes of calibration.

Thermal Converters and A.C. Range Multipliers

The Thermal Converter comprises a vacuo thermo junction with appropriate ranging resistors and gives a D.C. output proportional to the square of the input current. With such a unit connected to the 2.4 mV terminals of a Versatile Galvanometer, readings on the THERMAL scale represent the RMS value of the current or voltage applied to the converter.

Further ranges as indicated in the table below are obtained by connecting A.C. Range Multipliers to the Thermal Converter. It should be noted that separate voltage and current converters are necessary and that D.C. range multipliers cannot be used with thermal converters.

Thermal accessories measure true RMS values irrespective of waveform or superimposed D.C. In dealing with circuits having superimposed D.C. it should be remembered that the RMS value of the total current or voltage is measured.

VOLT RANGES (RED TERMINALS)				CURRENT RANGES (BLUE TERMINALS)			
Voltage Range 100 divs. Thermal Scale	Scale Multiplying Factor	Resistance. ohms.	Upper Frequency 5% error	Current Range 100 divs. Thermal Scale	Scale multiplying Factor	Resistance. ohms	Upper Frequency 5% error
.3*	.003	10	100 kc/s	.15A*	.0015	1	100 kc/s
.5	.005	16.67	,,	.5A	.005	.3	100 kc/s
1	.01	33.33	,,	1A	.01	.15	100 kc/s
2	.02	66.67	,,	2A	.02	.075	100 kc/s
5	.05	166.7	,,	5A	.05	.03	100 kc/s
10	.1	333.3	,,	10A	.1	.015	50 kc/s
50	.5	1,667	,,	20A	.2	.0075	20 kc/s
100	1	3,333	,,				
200	2	6,666	,,				
400	4	13,333	,,				
500	5	16,667	,,				

* Thermal Converter alone : Note that Voltage Converter alone provides an additional current range of 30mA for 100 divisions.

Frequency Range : Thermal accessories may be used on D.C. (provided that the mean of reversed readings is taken) or on A.C. from 1 c/s up to the limit indicated in table.

Temperature Coefficient : Volt Ranges —0.04% per C° Rise.
Current Ranges —0.1% per °C. Rise.

Accuracy and overload capacity : These accessories are adjusted so as not to introduce an error exceeding ± 1% of full scale reading. They will withstand overloads of up to 100% although there may be some subsequent change in calibration.

Ranged Vacuo Junctions

The frequency range of the Thermal Converter and A.C. Current Multipliers is limited by the inductance and stray capacities of the ranging resistors and multiplier shunts. For RMS current measurements over a wider range of frequency Ranged Vacuo Junctions should be used.

These units consist of a vacuum thermo junction with a couple circuit ranging resistor only, mounted in a 4-pin British valve base so that the frequency range is limited only by skin effects in the heater wire and stray capacities between the connector pins.

The Vacuo Junction may be plugged into any 4-pin British Valve base or into the special holder available for the purpose, and connected to the 2.4 mV range of the Versatile Galvanometer, when the RMS value of the heater current is indicated on the THERMAL scale of the indicator.

The following ranges are available :—

Current Range 100 divs. Thermal Scale	Scale Multiplying Factor	Resistance ohms
10mA	.1	30
20	.2	12
50	.5	8
100	1	1
200	2	.8
500	5	.4
1,000	10	.2

Temperature Coefficient of Indication : Approx. —0.1% per °C. Rise.

Accuracy and overload capacity : These accessories are adjusted so as not to introduce an error exceeding ± 1% of full scale reading. They will withstand overloads of up to 100% although there may be some subsequent change in calibration.

Frequency Range : These accessories may be used on D.C. or on A.C. between about 1 c/s and 20 Mc/s.

Unranged Vacuo Junctions

For current ranges outside those covered by the Ranged Junctions and for special applications the following series of unranged junctions is available. These are normally mounted on a 4-pin base, but can be supplied unmounted. A similar series of special construction is available for use at ultra high frequencies.

Nominal Current Range 6mV Output mA	Maximum Safe Current mA	Heater Resistance ohms.
1.25	2.5	1,600
2.5	5	400
5	10	90
10	20	30
25	50	12
50	100	4
100	200	1.4
250	500	0.6
500	1,000	0.4
1,000	1,500	0.15

These Vacuo Junctions may be adjusted to any convenient range by the addition of a manganin series resistor in the couple circuit when the calibration will fit, within a few per cent, the THERMAL scale of the Versatile Galvanometer.

When mounted they are suitable for use up to about 20 Mc/s. For higher frequencies either unmounted junctions of junctions of UHF pattern should be used. In the latter, the inductance and stray capacity of the heater is reduced to a minimum so that the frequency errors are determined almost entirely by normal skin effects and by the difficulty of defining the exact circuit conditions. UHF junctions are not available in ranges below 5 mA.

Resistance Accessory

This unit can be used only with special Versatile Galvanometers which are provided with an additional resistance scale. Such galvanometers are supplied only on request as it is considered that the extra scale may complicate the use of the instruments for the more normal purpose of measuring voltage and current.

The resistance scale is semi-logarithmic and with the accessory provides means of measuring resistances between .001 and 1,000 ohms.

The resistance accessory is connected to the 2.4 mV range of the indicator and requires in addition a 2 volt accumulator capable of discharging steadily at about 1 amp. An accuracy of approximately 2% is obtainable on the most favourable part of the scale.

The apparatus is standardised by turning the range switch to SET SCALE and bringing the pointer to full scale by means of the " Adjust Voltage " control. The resistance to be measured is connected to the X terminals, the value being given by the meter readings (on the resistance scale) multiplied by the range factor used.

The ON-OFF switch is connected in the battery circuit.

Power Measurement with Thermal Accessories

With any of the Thermal Accessories the meter indication as read on the linear mV scale is closely proportional to the current or voltage squared and consequently the equipment forms a convenient means of measuring the power associated with a non-inductive load circuit.

If I is the current in amps in a thermo junction or A.C. Current Multiplier corresponding to 100 divisions on the Thermal Scale and R is the resistance of the non-inductive load, then the power in the circuit is given by

$$W = .012\ I^2R \times \triangle$$

where $\triangle$ is the mV scale reading.

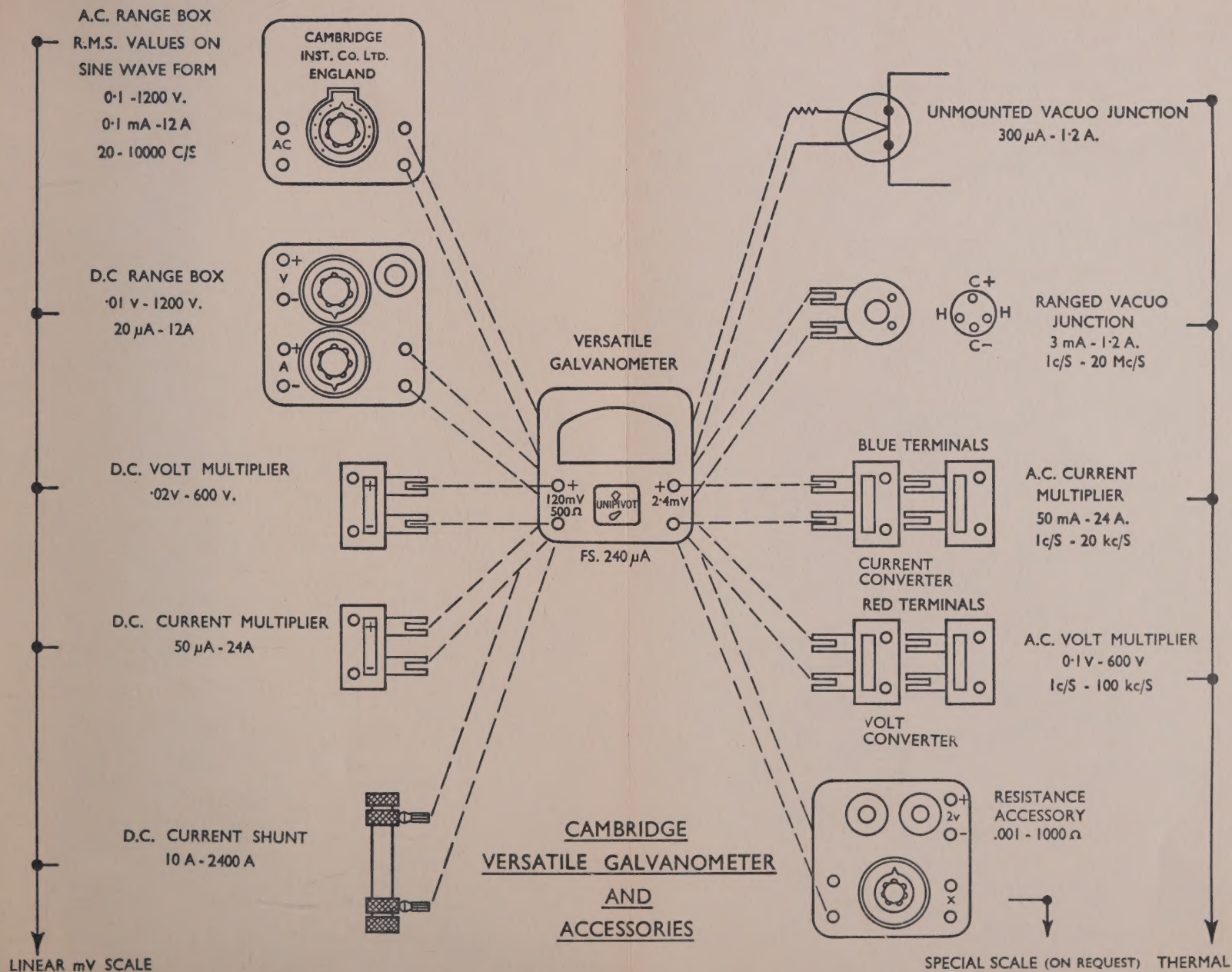
Similarly if an A.C. Voltage Multiplier is used across the load then the power is given by

$$W = .012\ \frac{E^2}{R} \triangle$$

where E is the voltage range of multiplier for 100 divisions on the Thermal scale, R is the load resistance and $\triangle$ the deflection on the mV scale.

In each case allowance must be made in computing R for the resistance of the ammeter of voltmeter circuit.

NOTE.—Where temperature coefficients have been quoted they must be accepted as approximate only. When the temperature coefficient is +ve the meter deflection for a given current or voltage increases as the temperature rises.


A.C. RANGE BOX
R.M.S. VALUES ON SINE WAVE FORM
0·1 -1200 v.
0·1 mA -12 A
20 - 10000 C/S
CAMBRIDGE INST. Co. LTD. ENGLAND
AC
D.C RANGE BOX
·01 v - 1200 v.
20 μA - 12A
V
A
D.C. VOLT MULTIPLIER
·02v - 600 v.
D.C. CURRENT MULTIPLIER
50 μA - 24A
D.C. CURRENT SHUNT
10 A - 2400 A
VERSATILE GALVANOMETER
120mV 500Ω
UNIPIVOT
2·4mV
FS. 240 μA
UNMOUNTED VACUO JUNCTION
300 μA - 1·2 A.
C+
H
H
C−
RANGED VACUO JUNCTION
3 mA - 1·2 A.
1c/S - 20 Mc/S
BLUE TERMINALS
A.C. CURRENT MULTIPLIER
50 mA - 24 A.
1c/S - 20 kc/S
CURRENT CONVERTER
RED TERMINALS
A.C. VOLT MULTIPLIER
0·1 V - 600 V
1c/S - 100 kc/S
VOLT CONVERTER
2v
RESISTANCE ACCESSORY
.001 - 1000 Ω
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VERSATILE GALVANOMETER
AND
ACCESSORIES
LINEAR mV SCALE
SPECIAL SCALE (ON REQUEST)
THERMAL SCALE

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